Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number

Learner Registration Number

Pearson BTEC Level 3 Nationals Diploma, Extended Diploma

Time 50 minutes

Paper reference **31627H/1C**

Applied Science

UNIT 5: Principles and Applications of Science II Chemistry
SECTION B: PROPERTIES AND USES OF SUBSTANCES

You must have:
A calculator and a ruler.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and learner registration number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The exam comprises three papers worth 40 marks each.
  - Section A: Organs and systems (Biology).
  - Section B: Properties and uses of substances (Chemistry).
  - Section C: Thermal physics, materials and fluids (Physics).
- The total mark for this exam is 120.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- The periodic table of elements can be found at the back of this paper.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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Answer ALL questions. Write your answers in the spaces provided.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 (a) Aluminium is a metal.

Figure 1 shows some aluminium cans used to store drink.

Figure 1

Give **two** properties of aluminium that are important when the metal is used for drink cans.

(2)

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(b) Aluminium is produced from an ore.

The ore contains aluminium oxide.

(i) Identify the name of the ore.

(1)

- ☒ **A** bauxite
- ☒ **B** cryolite
- ☒ **C** ilmenite
- ☒ **D** rutile

(ii) Equation 1 shows a reaction of aluminium oxide.

$$Al_2O_3 + 2\,NaOH + \ldots\ldots\ldots H_2O \rightarrow \ldots\ldots\ldots NaAl(OH)_4$$

Equation 1

Add numbers to balance Equation 1.

(2)

(iii) Aluminium oxide reacts with sodium hydroxide.

Calcium oxide does not react with sodium hydroxide.

Aluminium oxide and calcium oxide both react with hydrochloric acid.

Complete Table 1 to show whether each compound is an acid, a base or both.

(3)

compound	acid	base
aluminium oxide	☒	☒
calcium oxide	☒	☒
sodium hydroxide	☒	☒

Table 1

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(c) Electrolysis can be used to produce aluminium and oxygen from aluminium oxide.

Electrolysis takes place in an electrolytic cell.

Figure 2 shows a diagram of the electrolytic cell.

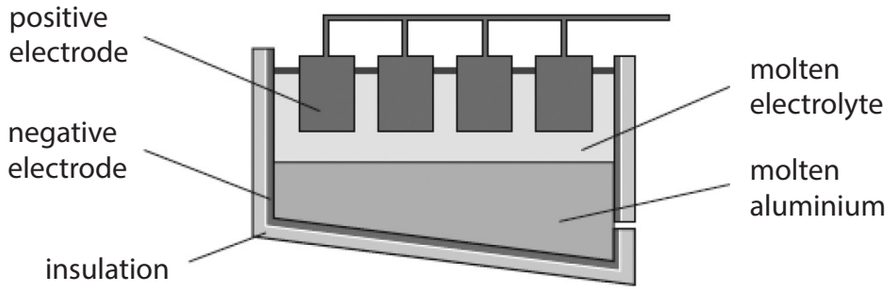

Figure 2

(i) Describe how electrolysis can be used to produce aluminium from aluminium oxide.

(2)

(ii) Give **one** reason why electrolysis, rather than reduction with carbon, is used to extract aluminium.

(1)

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(iii) The electrolysis of sodium chloride solution (brine) uses a membrane cell.

Explain why a membrane cell is **not** needed in the electrolysis of aluminium oxide.

You may refer to Figure 2 in your answer.

(2)

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(Total for Question 1 = 13 marks)

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2 Alkanes undergo combustion reactions.

(a) Complete Paragraph 1.

(1)

Combustion reactions are examples of open systems.

In open systems, energy and matter are exchanged between the system and the

.....

Paragraph 1

(b) Fuel for cars contains the alkanes heptane (C_7H_{16}) and octane (C_8H_{18}).

Equation 2 shows the combustion of heptane.

$$C_7H_{16}(l) + 11O_2(g) \longrightarrow 7CO_2(g) + 8H_2O(l) \qquad \Delta H = -4187 \text{ kJ}$$

Equation 2

Equation 3 shows the combustion of octane.

$$C_8H_{18}(l) + 12.5O_2(g) \longrightarrow 8CO_2(g) + 9H_2O(l) \qquad \Delta H = -5512 \text{ kJ}$$

Equation 3

(i) Give **one** reason why Equation 2 and Equation 3 show the standard enthalpy change of combustion.

(1)

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.....

(ii) State what is meant by the negative sign for ΔH in Equations 2 and 3.

(1)

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(iii) State what the difference in ΔH indicates about Equations 2 and 3.

(1)

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(c) A scientist is investigating the pressure in the piston of a car engine during combustion.

The scientist's data is shown in Figure 3.

Enthalpy change (ΔH)	=	–4100 J
Internal energy change (ΔU)	=	–4300 J
Initial volume of gas in piston	=	1.0×10^{-4} m^3
Final volume of gas in piston	=	6.0×10^{-4} m^3

Figure 3

Calculate the pressure (p) acting on the piston.

(4)

Use the equation: $\Delta H = \Delta U + p\Delta V$

Show your working.

p = ... Pa

(Total for Question 2 = 8 marks)

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3 Figure 4 shows four reactions of *cis*-but-2-ene.

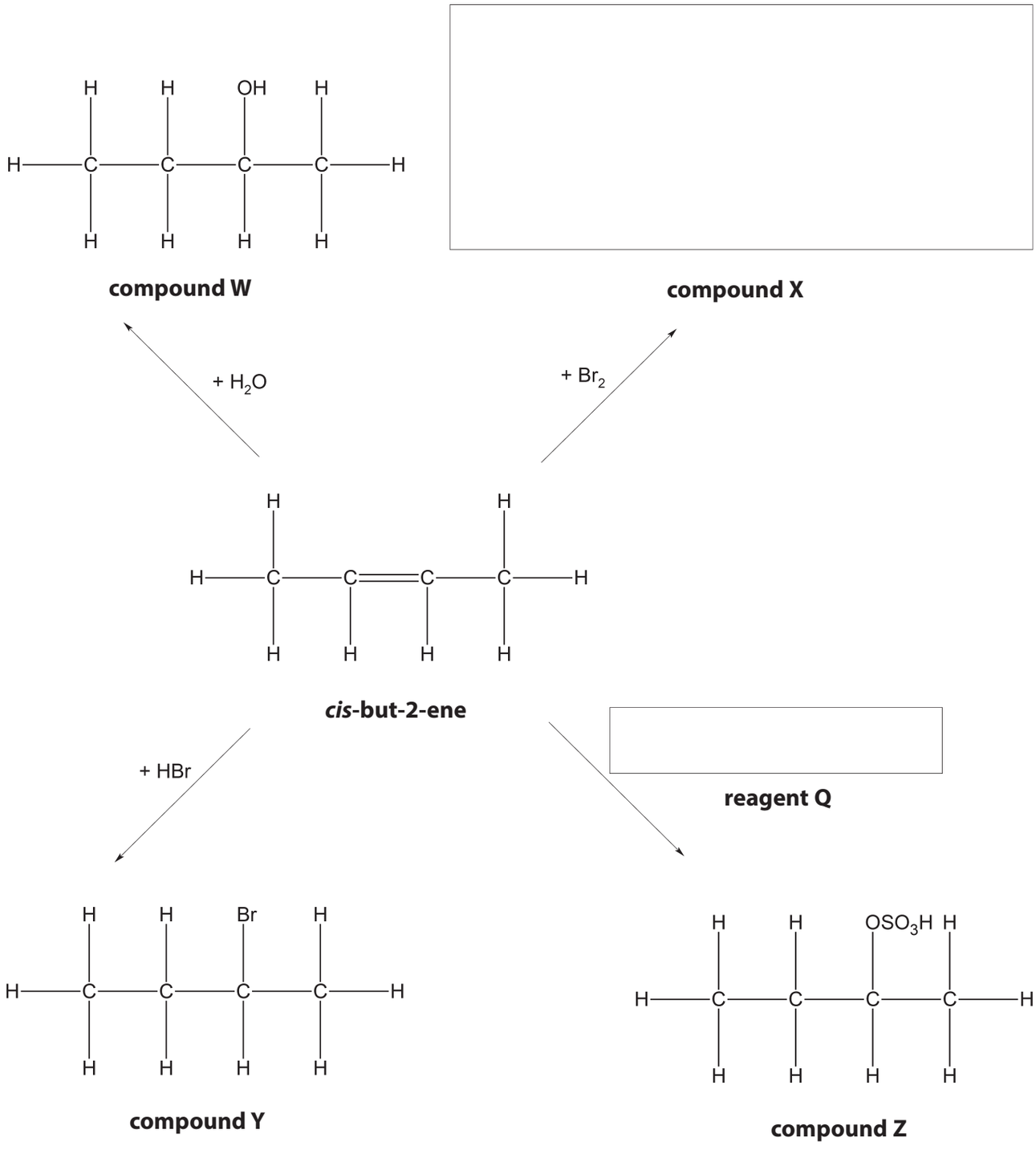

Figure 4

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(a) (i) Identify the name of compound W shown in Figure 4.

(1)

- ☒ **A** butan-1-ol
- ☒ **B** butan-2-ol
- ☒ **C** butan-3-ol
- ☒ **D** butan-4-ol

(ii) Draw the structural formula of compound X in the space provided in Figure 4.

(1)

(iii) Write the formula of reagent Q in the space provided in Figure 4.

(1)

(b) The HBr molecule acts as an electrophile in the addition reaction with *cis*-but-2-ene.

(i) Explain what the word 'electrophile' means.

(2)

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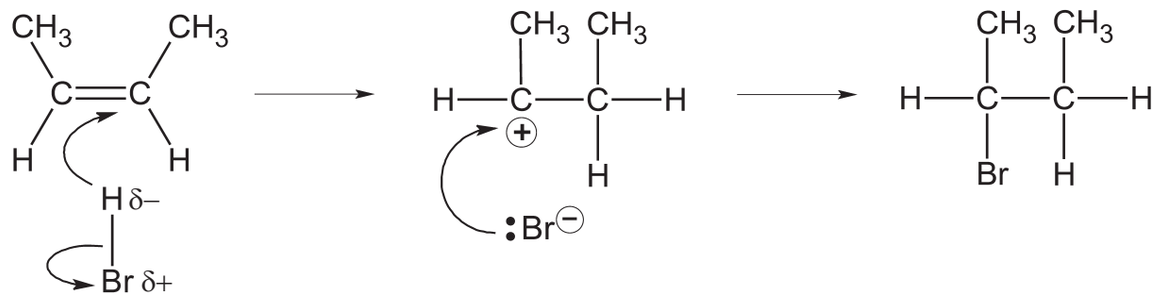
(ii) Figure 5 shows an incorrect mechanism for *cis*-but-2-ene with HBr.



Step 1 **Step 2**

Figure 5

There are two errors in Step 1 of the mechanism.

Explain the **two** errors in Step 1 of Figure 5.

(4)

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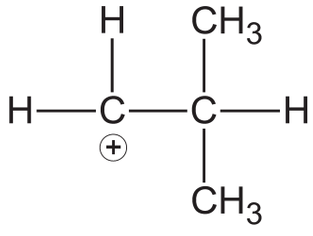
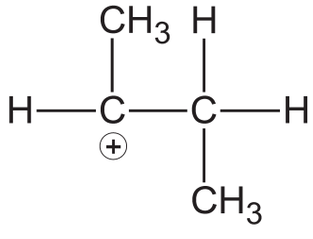
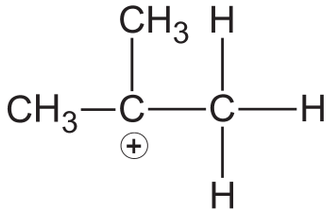
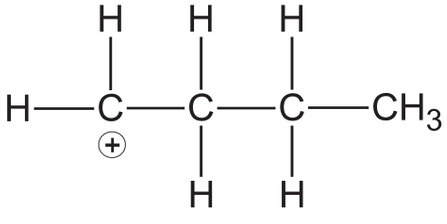
(iii) The formula of the carbocation in Step 2 of the mechanism is $C_4H_9^{\oplus}$.

There are several different structural isomers of $C_4H_9^{\oplus}$.

Identify the most stable $C_4H_9^{\oplus}$ carbocation.

(1)

☒	**A**	
☒	**B**	
☒	**C**	
☒	**D**	

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(c) But-1-ene is a structural isomer of *cis*-but-2-ene.

The skeletal formulae of but-1-ene and *cis*-but-2-ene are shown.

but-1-ene

***cis*-but-2-ene**

When HBr is added to but-1-ene, two products are formed.

When HBr is added to *cis*-but-2-ene, only one product is formed.

Explain why but-1-ene can form **two** products, but *cis*-but-2-ene can only form **one** product.

(3)

(Total for Question 3 = 13 marks)

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4 Iron (Fe) is used as a solid catalyst in the Haber process reaction:

$$N_2\,(g) + 3H_2(g) \rightleftarrows 2NH_3\,(g)$$

Iron ions are used to catalyse the reaction between persulfate ($S_2O_8^{2-}$) and iodide (I^-) ions.

The catalysed reaction happens in two steps involving Fe^{2+} and Fe^{3+} ions.

Step 1: $S_2O_8^{2-} + 2Fe^{2+} \longrightarrow 2SO_4^{2-} + 2Fe^{3+}$

Step 2: $2I^- + 2Fe^{3+} \longrightarrow I_2 + 2Fe^{2+}$

Discuss how iron and iron ions behave as catalysts in these reactions.

(6)

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(Total for Question 4 = 6 marks)

TOTAL FOR SECTION B = 40 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)											(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Key: relative atomic mass / **atomic symbol** / name / atomic (proton) number

* Lanthanide series

* Actinide series

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

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